Table 5.1 Key information from Protocol Development Summaries (PDS) for each of the top 18 vital signs (see Appendix 4).

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Weather and Climate (1)	The Weather/Climate vital sign is ranked first among all of the potential vital signs evaluated by the SFAN. Knowledge about weather and climate is critical because they affect not just geophysical and biological resources but ecosystem drivers and processes. Key reasons for monitoring weather and climate in network parks are because the effects can be long-lasting on (1) plant and animal populations, some of which are listed as endangered or threatened species, (2) on air and water quality, and (3) on drought and flood cycles, fires, mass wasting and other catastrophic events. Long-term weather data can also contribute to the understanding of global climate change and its effects on Network ecosystems.	Determine variability and long-term trends in climate through monthly and annual summaries of selected weather parameters (temperature and precipitation). Identify and determine frequencies and patterns of extreme climatic conditions for common weather parameters.	EUON, GOGA, JOMU, PINN, PORE
Invasive Plant Species (early detection) (2)	Invasive plant species ranked second in the prioritized list of vital signs to be monitored for ecosystem changes and trends. Early detection of invasive plant species is a proven method for preventing the establishment of new species and limiting the spread of existing species into uninfested areas. This protocol provides information that can be used immediately by park managers to target new or expanding infestations. The data can also track long-term infestation patterns and potentially evaluate long-term effectiveness of invasive species management.	Develop and maintain a list of target species that do not currently occur in the parks, occur in localized areas of parks, or are extremely rare, but that would cause major ecological or economic problems if they were to become established. Detect new species and new populations of invasive species before they become established in areas of high and moderate management importance.	FOPO GOGA, JOMU, MUWO, PINN, PORE, PRES

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Freshwater Quality (3)	The SFAN has many unique aquatic resources that are significant in an ecological and economic context. Freshwater systems within the network support a variety of threatened and endangered species. Freshwater quality has direct impact on several other vital signs including: marine water quality, stream T&E species and fish assemblages, T&E amphibian and reptiles, riparian habitat, wetlands, and aquatic macroinvertebrates. Freshwater quality also indirectly impacts plant and animal life. In addition, Tomales Bay is a major commercial shellfish growing area. The Tomales Bay Pathogen Total Maximum Daily Load (TMDL) program requires NPS to conduct fecal coliform analysis of streams entering the bay to ensure that allowable standards are not exceeded.	Determine variability and long term trends in water quality through monthly summaries of select parameters (temperature, pH, conductivity, dissolved oxygen, total nitrogen, nitrate, ammonia, flow, fecal and total coliforms), in priority freshwater sites. Determine the existing ranges and diurnal variability of water temperature, pH, conductivity, and dissolved oxygen at selected sites in priority streams within SFAN. Determine the extent that priority streams within SFAN meet federal and state water quality criteria for fecal indicator bacteria, un-ionized ammonia, dissolved oxygen, and pH through monthly sampling. Determine the annual, seasonal, and 30-day mean fecal coliform load to Tomales Bay (in impaired water body) from Olema Creek as required by the San Francisco Bay Regional Water Quality Control Board's Tomales Bay Pathogen TMDL Program.	GOGA, JOMU, PINN, PORE
Air Quality (4)	Clean unpolluted air is essential for all life on earth. Air quality is linked to many natural processes, i.e. soil and water nutrients, photosynthesis, acidification of lakes and streams. PINN and PORE are rated as Class 1 areas by the Clean Air Act and are protected by strict air quality regulations. The rest of the parks in the SFAN are Class 2 areas and pollution regulations are less strict. However, in some instances federal land managers apply the “precautionary principle” and treat Class 2 areas with the same standards as Class 1 Areas.	Report on seasonal and annual status and trends of N and S concentration and deposition in precipitation at existing monitoring stations in SFAN parks. Report on seasonal and annual status and trends of fine particle concentrations and composition at existing monitoring stations in SFAN parks. Report on seasonal and annual status and trends of ozone concentrations in NCRN parks using metrics that are indicative of human health (e.g., 8-hour average) and plant response (e.g., SUM06).	GOGA, PINN, PORE

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Stream Fish Assemblages (5)	As an indicator of ecological health of freshwater stream systems, this vital sign category includes monitoring for a suite of species and conditions within stream aquatic habitat including habitat condition, fish assemblage, population, and community structure, as well as three threatened and endangered species: coho salmon (*Oncorhychus kisutch*); steelhead trout (*O. mykiss*); and the California freshwater shrimp (*Syncharis pacifica*). Coho salmon and steelhead are anadromous and the life stage requirements demand year-round, high-quality cold water, continuous riparian cover, and complex habitat and structure to accommodate development from egg to smolt stage. Monitoring of these species at multiple life stages is valuable to the understanding of aquatic conditions and a good measure of watershed health. Because coho salmon and steelhead live for more than a year in freshwater, and the conditions required to support them are highly restrictive, they are susceptible to anthropogenic impacts to the stream and riparian systems. Because salmonids are sensitive to watershed and habitat impacts, they are effective indicators of stream and aquatic health. The California freshwater shrimp are also highly sensitive to water quality and changes to habitat.	Determine long-term trends in size and age class distribution and production of salmonid smolts through spring trapping at select streams at PORE, MUWO, and GOGA. Determine long-term trends in timing and distribution of salmonid spawning, adult sex ratios, and escapement in select streams at PORE and GOGA. Track the distribution and relative abundance of California freshwater shrimp within known freshwater shrimp habitat in SFAN. Determine the trends in distribution, abundance, composition, and size/age structure of fishes at summer index reaches of SFAN streams of PORE, MUWO, and GOGA. Measure the long-term trends in distribution and assemblage of fish species through annual spring surveys of Chalone Creek at PINN. Measure the long-term trends in the annual fish assemblage, distribution and abundance through fish surveys within the NPS managed section of Franklin Creek at JOMU.	GOGA, JOMU, PINN, PORE

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Rare Plant Species (6)	PORE has over 50 plant species with federal, state or local status. GOGA has over 35 plant species, including those at PRES, with federal, state or local status. The inventory for PINN needs to be refined and better documented, but there is currently evidence for over 10 sensitive species. In the summer of 2004, a ranking system was developed to help the parks determine which species are the "most rare" within the park boundaries regardless of official listing status. A different version of the ranking matrix will be used to determine which species are the most appropriate for long-term monitoring for trends and ecosystem health. We are developing a systems approach to monitoring rare plants, while also addressing management needs. This vital sign is also part of a hierarchy of vegetation monitoring being developed by the working group, in which some rare species will be monitored via the plant community change protocols.	Develop and maintain a list of target rare species based on a regional rarity matrix and in order to prioritize RTE monitoring efforts. Determine long-term trends of population abundance by conducting species specific surveys as needed of mapped populations. Identify potential threats (e.g. visitor trampling, presence and encroachment of invasive plant species, pest infestation), and estimate degree of threat to rare species at mapped locations in order to identify management needs. Monitor suitable habitats every 5-10 years in order to identify presence/absence of target species and incorporate them into annual abundance estimates.	GOGA, PORE, PRES, PINN
Northern Spotted Owl (7)	The federally threatened status of this species requires the NPS monitor the long-term status and trend of the population and maintain stable or increasing populations of spotted owls. Owls are also good indicators of forest ecosystem condition because they area associated with multi-tiered, old growth forests. This monitoring program provides the data required to accurately assess the status and trend of this isolated, potentially vulnerable spotted owl population, where it occupies a land use matrix strikingly different from that found throughout most of the owl's range. Our monitoring program contributes to the Northwest Forest Plan which is working to arrest the downward trend in spotted owl populations and in maintaining and restoring the habitat conditions necessary to support viable populations of the northern spotted owl. The program has an eight-year history of monitoring spotted owls in the SFAN parks, which contributes to region and range-wide monitoring programs and park management activities.	Monitor changes in spotted owl abundance and reproductive success at known owl activity sites within the NPS legislated boundaries of Marin County, California. Determine the long-term changes of nest site characteristics (e.g. tree species selected for nest sites, vegetation community selected for nest sites) at Northern Spotted Owl at known activity sites in order to evaluate habitat selection. Monitor suitable habitats every 5-10 years in order to identify population expansion of target species and incorporate them into annual abundance estimates.	MUWO, PORE

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Amphibians and Reptiles (8)	Due to their habitat and physiology, these taxa are particularly sensitive to environmental degradation, such as air and water pollution. The number of species and populations of amphibians are declining worldwide. Because they are mid-level predators, population trends in these taxa may indicate trends in populations of animals at both higher and lower trophic levels. Standard protocols are available for sampling these animals in the San Francisco Bay Area, in some cases long-term data sets already exist. In addition to monitoring the two federally protected herptile species found in the network, the protocol will also address monitoring of terrestrial amphibian and reptile assemblages.	Determine variability and long-term trends in amphibian and reptile assemblages in key terrestrial habitats. Determine relative abundance of populations of key threatened and endangered amphibians and reptiles, such as California red-legged frogs (*Rana aurora draytonii*) and the San Francisco garter snake (*Thamnophis sirtatlis tetrataenia*) within the network parks. Determine distribution of populations of key threatened and endangered amphibians and reptiles within the network parks. Monitor habitat variables at breeding sites for the key threatened and endangered species.	PORE, GOGA, PINN, JOMU, MUWO, PRES
Western Snowy Plover (9)	Western snowy plovers are listed as federally threatened under the Endangered Species Act. They are also part of the coastal dune ecosystem, which is identified in the PORE enabling legislation. Western snowy plovers are good indicators of the condition of the coastal dunes ecosystem and are the only nesting shorebird in the coastal strand. There is a long history of monitoring snowy plovers at PORE and GOGA. in collaboration with other organizations and agencies. Several park management actions, including major dune habitat restoration projects to enhance the recovery of snowy plovers.	Determine long-term changes in the breeding population size, distribution, and reproductive success of snowy plovers at known breeding beaches at PORE. Determine changes in wintering population size and distribution of snowy plovers at known wintering beaches at GOGA and PORE. Determine trends in pollutant loads (e.g. mercury and selenium) in plover eggs, chicks, and adults, as funds are available in order to evaluate potential hazards. Monitor suitable habitats every 5-10 years in order to identify population expansion of target species and incorporate them into annual abundance estimates.	GOGA, PORE

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Pinnipeds (10)	Pinnipeds come under the legal mandates of the Endangered Species Act and Marine Mammal Protection Act. They are also specifically identified in the enabling legislation of and management objectives of PORE. Pinnipeds are good indicators of the condition of the marine ecosystem and global climate change because they respond quickly to oceanic conditions and food resources, such as El Nino events. There is a long history of monitoring pinnipeds at PORE and GOGA in collaboration with other agencies and organizations. Identifying natural and anthropogenic threats and quantifying the level of disturbance to harbor seals will also be critical in order to effectively manage and protect pinnipeds.	Determine long-term trends in annual population size and annual and seasonal distribution of pinniped populations at PORE and GOGA. Determine long-term trends in reproductive success of elephant seals and harbor seals populations through annual estimates of productivity at PORE and GOGA. Identify potential threats (i.e. presence of hikers, motor boats, or airplanes presence), and estimate degree of threat at harbor seal haul outs in order to identify management needs.	GOGA, PORE
Plant Community Change (11)	Numerous biotic and abiotic factors have altered and continue to threaten plant communities within SFAN. As plant communities continue to recover from past resource extraction and grazing, there is a need to understand how current activities are effecting this recovery. It is also important to monitor and evaluate changes to the composition of plant communities and type changes occurring on the landscape. The monitoring program proposed assimilates multiple vital signs including invasive plant species, threatened and endangered plant species, wetlands, grassland plant communities, oak woodlands, and plant species at the edge of their range. There are also significant ties between plant community change and almost all of the faunal indicators being monitored such as landbirds, Northern spotted owls, endangered butterflies, etc.	Develop and maintain a list of priority plant communities based on their rarity and degree of protection. Detect long-term trends in native and non-native abundance and distribution within selected plant communities. Detect changes in overall vegetation cover, vegetation type and species composition of selected SFAN plant communities through monitoring every 7-10 years.	FOPO, GOGA, JOMU, MUWO, PINN, PORE, PRES

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Landscape Dynamics (12)	Key reasons for monitoring regional landscape & land use change are (1) the rapid development of neighboring lands (2)the fragmentation of wildlife habitat (3) the need to detect life-form change within parks, and (4) to provide early warning of large-scale community shifts.	Determine status and trends in the areal extent and configuration of land-cover types (Anderson Level II) on park lands in order to evaluate large scale changes affecting park resources. Determine status and trends of key landscape metrics (e.g. proportion of area in different cover types, number and density of patches, mean patch size) of park lands and a ½ mile buffer in order to determine land use patterns in the parks.	EUON, FOPO, JOMU, GOGA, MUWO, PINN, PORE, PRES
Threatened and Endangered (T & E) Butterflies (13)	The protected legal status of these taxa require the NPS to evaluate the condition of these populations. Because they are closely tied to host and nectar plants, butterfly populations are good indicators of general health of habitat.	Determine the trends in population distribution and abundance of threatened and endangered butterflies within known habitats in GOGA and PORE. Detect changes in acreage of habitat available for butterfly populations at GOGA and PORE such that potential impacts on the butterfly populations may be identified. Predict and identify new lupine habitat annually in order to identify new butterfly populations.	GOGA, PORE
Freshwater Dynamics (14)	Freshwater Dynamics is ranked 14th among all of the potential vital signs evaluated by the SFAN. Streamflow characteristics offer some of the most appropriate and useful indicators for assessing river ecosystem integrity over time. The hydrologic output of a watershed is a function of the land characteristics and human use, the weather and climate conditions, urbanization and soil characteristics. Hydrologic variation plays a key part in structuring the biotic diversity within river ecosystems by controlling critical habitat conditions within the river channel, the floodplain, and hyporrheic zones. Stream hydrology data provides key "support" data for vital signs including stream T&E species and fish assemblages, T&E amphibians and reptiles, wetlands, and riparian habitat.	Monitor the variability and long-term trends in stream flow based on monthly and storm event-related discharge measurements at fixed stations in GOGA, JOMU, MUWO, PINN, and PORE. Monitor the frequency, magnitude and duration of peak flow events at fixed water level monitoring stations by producing instantaneous peak, hourly, daily, monthly and annual summaries of stage height and discharge in GOGA, JOMU, MUWO, and PORE. Monitor the frequency, magnitude and duration of unnatural or extreme low water/low flow events in stream reaches known to support threatened and endangered aquatic species in the dry season at GOGA and PORE.	GOGA, JOMU, PINN, PORE

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Wetlands (15)	Wetlands are keystone ecosystems in the San Francisco Bay Area. Some ecologists call wetlands "the kidneys of the landscape" as they provide water quality protection, flood and drought mitigation, erosion control, and groundwater recharge functions. Wetlands support complex food webs, housing a rich biodiversity of wetland-endemic species, and providing habitat functions for many aquatic and terrestrial species. An estimated 46% of US endangered and threatened species and 50% of all bird species require wetland habitat (USFWS). Wetland habitats are vulnerable to alteration due to global climate change and associated potential temperature, hydrology, and salinity regime changes. Understanding the condition of wetlands may be a good proxy for understanding the condition of many taxa of concern in the network.	Determine if the extent, type, condition and function of wetlands is changing.	GOGA, JOMU, MUWO, PINN, PORE, PRES
Riparian Habitat (16)	Riparian habitat is closely tied to the health of wetlands, streams and stream fish assemblages. Characteristics of riparian habitat structure such as the ratio of edge to interior, the degree of canopy complexity within riparian strata (e.g., herb/forbs, shrubs, sub-canopy tree, and overstory tree), and the degree of fragmentation is highly associated with amount and type wildlife use.	Determine status and trend of riparian habitat by measuring species composition, habitat structure, and width along streams in SFAN parks.	GOGA, JOMU, MUWO, PINN, PORE, PRES
Landbird Population Dynamics (17)	Landbirds are good indicators of terrestrial ecosystems and numerous dynamic processes interacting together have the potential to affect their abundance and distribution. Landbird monitoring is focused in priority areas including riparian and coastal scrub/chaparral habitats. Changes in species abundance, distribution, reproductive success, and annual survival may be caused by changes in habitat, food supply, park management strategies, disturbance to nesting areas by recreational users, or environmental factors on multiple scales (localized storm events to decadal shifts in climate).	Determine the annual changes in species composition, distribution, and abundance for landbirds in priority habitats including riparian and coastal scrub / chaparral habitats. Determine long-term changes in reproductive success of landbirds in priority habitats including riparian and coastal scrub / chaparral habitats. Determine long-term changes in annual survival for landbirds in priority habitats including riparian and coastal scrub / chaparral habitats.	GOGA, JOMU, PINN, PORE, PRES

Vital sign Name (rank)	Justification	Monitoring Objectives	Parks Involved
Raptors and Condors (18)	Long-term trends in the nesting success and productivity of prairie falcons provide a means for assessing the park's ability to adequately manage climbing use and the overall ecological integrity and sustainability of the rock/cliff ecosystem. Long-term patterns in population size and breeding behavior (e.g. feeding rates of chicks) are compared to long-term climate change, effects of conversion and development of agricultural lands surrounding the monument, and visitor use of the monument. This information will improve the understanding of raptor ecology and the effects of park management decisions.	Determine annual nesting success at Pinnacles NM as measured by territories occupied, number of chick produced and number of chicks fledged. Monitor potential threats (i.e. presence of hikers or climbers), and estimate degree at nesting sites in order to identify management needs.	PINN